grating in contact with the fluid and formed on a first member; an interrogation device providing ultrasound that passes through at least a portion of the first member and is incident on the diffraction grating at an angle of incidence; a detector for capturing a reflection spectrum from the diffraction grating when the ultrasound is incident on the diffraction grating, the reflection spectrum including a diffraction order equal to zero; and a processing device receiving an output of the detector for determining a value corresponding to a property of the fluid based upon the reflection spectrum. The processing device can be operable to determine the value by selecting a wavelength corresponding to a peak in the reflection spectrum. The property of the fluid can be speed of sound in the fluid. The interrogation device can include a transducer face in acoustic contact with the first member. The transducer face can be spaced from the diffraction grating a distance at least about equal to $D^2/(4\lambda)$ where D is the smallest dimension of the transducer face and λ is the wavelength of the ultrasound in the solid material. The grating can include at least 20 grooves with a period between about 50 μm and about 500 μm. The grating can include grooves with a triangular cross section. The angle of incidence can be between about 25 and about 50°. The first member can be stainless steel. There can also be a second member comprised of solid material and having first and second opposed surfaces with a transducer in acoustic contact with the first surface and the second surface in contact with the fluid. The transducer in acoustic contact with the first surface of the second member can be coupled to a processing device operable to determine a value corresponding to acoustic impedance of the liquid from a decay rate of ultrasound reflected between the first and second surfaces of the second member.

[0137] Still another form is a method for determining a property of a fluid comprising interrogating a diffraction grating in contact with the fluid with ultrasound at an angle of incidence by passing the ultrasound through a member comprised of solid material and having the diffraction grating having a grating period formed on a face thereof, receiving a response to the interrogating wherein the response includes a reflection spectrum of ultrasound reflected at a predetermined angle relative to the normal of the diffraction grating; and determining first value corresponding to a property of the fluid by selecting a peak in the reflection spectrum. Determining the value can include comparing the value to a value for a calibration sample. The interrogation can be performed with a transducer having a face spaced from the grating a distance at least about equal to $D^2/(4\lambda)$ where D is the smallest dimension of the transducer face and λ is the wavelength of the ultrasound in the solid material. A second value corresponding to density of the fluid can be determined from the first value and a third value corresponding to acoustic impedance. This third value can be determined by reflecting an ultrasound pulse a multiplicity of times between a pair of opposed surfaces one of which is in contact with the fluid.

[0138] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes, equivalents, and modifications that come within the scope of the inventions described herein or defined by the following claims are desired to be protected.

Any experiments, experimental examples, or experimental results provided herein are intended to be illustrative of the present invention and should not be construed to limit or restrict the invention scope. Further, any theory, mechanism of operation, proof, or finding stated herein is meant to further enhance understanding of the present invention and is not intended to limit the present invention in any way to such theory, mechanism of operation, proof, or finding. In reading the claims, words such as "a", "an", "at least one", and "at least a portion" are not intended to limit the claims to only one item unless specifically stated to the contrary. Further, when the language "at least a portion" and/or "a portion" is used, the claims may include a portion and/or the entire item unless specifically stated to the contrary.

What is claimed is:

1. A system for determining a property of a multiphase fluid comprising:

at least one diffraction grating in contact with the fluid;

at least one interrogation device providing ultrasound incident on the at least one diffraction grating;

at least one detector for capturing at least one reflection spectrum from the at least one diffraction grating when the ultrasound is incident,on the at least one diffraction grating; and

a processing device receiving an output of the at least one detector for determining at least one value corresponding to a property of the multiphase fluid based upon the at least one reflection spectrum.

2. The system of claim 1 wherein the multiphase fluid includes solids in a liquid, and the at least one determined value corresponds to a size or a concentration of solids in the liquid.

3. The system of claim 2 wherein the processing device is operable to calculate a size or a concentration of the solids in the fluid based on a value corresponding to an integration or a peak height in the reflection spectrum.

4. The system of claim 1 wherein the at least one diffraction grating includes first and second different diffraction gratings.

5. The system of claim 4 wherein the diffraction gratings have different grating periods.

6. The system of claim 4 wherein the diffraction gratings are comprised of different solid material.

7. The system of claim 4 wherein the multiphase fluid includes solids in a liquid and wherein the at least one value includes a first value and a second value, the first value corresponding to a size of the solids in the liquid and the second value corresponding to a concentration of the solids in the liquid.

8. The system of claim 1 wherein the at least one reflection spectrum includes at least two different diffraction orders.

9. The system of claim 8 wherein the multiphase fluid includes solids in a liquid and wherein the at least one value includes a first value and a second value, the first value corresponding to a size of the solids in the liquid and the second value corresponding to a concentration of the solids in the liquid

10. A system for determining a property of a fluid comprising: